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Direct air capture versus post combustion capture for coal fired power plants: Energy balance and life cycle environmental assessment

Christoph Meinrenken
Columbia University, cmeinrenken@ei.columbia.edu

DIRECT AIR CATPURE VERSUS POST COMBUSTION CAPTURE FOR COAL FIRED POWER PLANTS: ENERGY BALANCE AND LIFE CYCLE ENVIRONMENTAL ASSESSMENT

Christoph Meinrenken, Earth Institute, Columbia University, New York, NY
cmeinrenken@ei.columbia.edu

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Direct air capture (DAC) has been suggested as a possible alternative to post combustion capture (PCC), as a way to lower the climate impact of fossil-based electricity generation. However, various literature suggests that the much lower concentration of CO2 in ambient air (compared to flue gas) will cause DAC to require ~3x higher energy consumption than PCC per ton CO2 captured, in turn leading to impractically high parasitic loads, costs, and potentially other adverse environmental impacts of DAC for purposes of mitigating emissions from e.g. coal-fired power plants. Here we present a comparative techno-economic and life cycle assessment (LCA) of moisture-swing based DAC versus amine-based PCC. Our particular focus is on elucidating the energy consumption of the process, of the thermodynamic limit versus DAC versus PCC, and the relative amounts of electricity versus heat as different components of that energy consumption. This shows that the electricity consumption of moisture-based DAC is much more moderate than could have been expected. Furthermore, DAC has the capability of capturing CO2 emissions not only from coal combustion but also from all life cycle background processes of coal-based electricity. Using LCA, we show that moisture swing-based DAC can enable net-zero carbon electricity from coal while incurring only moderate increases in 10 other key environmental impacts.